

Report on Work Carried out on NASA Grant NAGW 3525  
**"Theoretical Studies of Polar Stratospheric Clouds and the Background  
Stratospheric Sulfate Aerosol"**

**Introduction**

This report describes the work done with funding from NASA Grant NAGW 3525 during 1995. The grant was initiated in March, 1992 and has a planned duration of three years. This report covers the time period March 1995 to Present.

In this report I present a short description of the projects carried out and documentation of the work done in terms of papers presented, etc.

**Projects Completed or in Progress**

**1. An analysis of homogeneous nucleation using a stochastic approach.**

This work is finished. I have been working in collaboration with a student of mine, Mr. Terry Olson. We have prepared a paper discussing our analysis of kinetic nucleation. We found several interesting aspects of the mathematical analysis of nucleation which have not been previously considered. The paper has been accepted for publication in the Journal of Chemical Physics.

**2. Finished work on the development of a model for polar stratospheric clouds.**

This model predicts the growth and sedimentation of NAT polar stratospheric cloud particles. The model is finished but no papers have yet been written on this topic.

**4. Incorporation of microphysics into a Pinatubo aerosol model.**

We are incorporating aerosol microphysics into a dispersion model for the Pinatubo cloud developed by Rich Young and Howie Huben. It is interesting to note that the nucleation and coagulation of the Pinatubo aerosol particles is extremely fast, and essentially complete within a few days. These results were presented at the NATO meeting in Rome in October, 1994. A paper describing this work has been submitted for publication.

## **5. Analysis of the blue sun phenomenon.**

Following Pinatubo, it was reported that “blue sun” size distributions were present, as indicated by sun photometer data. There were, however, no visual sightings of blue suns, probably because of tropospheric effects. We have developed a model to study this effect and have obtained interesting results.

## **6. Study of aerosol optical depths.**

This work was carried out in collaboration with Phil Russell and other investigators. We used a variety of different measurement techniques to obtain an integrated picture of the stratospheric aerosol following the eruption of Pinatubo. The results are presented in a journal article that has been submitted to the Journal of Geophysical Research.

## **7. Growth of ternary system particles.**

An interesting question is the growth of ternary system (sulfuric acid, water, and nitric acid) aerosols in the winter stratosphere. I have finished the development of a model for the heteromolecular growth of such particles and a paper describing the results has been accepted for publication in Geophysical Research Letters.

## **8. Formation of particles at tropical tropopause.**

When the ER-2 landed and took off from Nadi, Fiji during the ASHOE/MAESA program, the Denver University (Wilson, Brock and Hafladi) impactor showed a huge increase in small particles. I carried out a nucleation calculation and found that the tropical tropopause could be a source of the stratospheric particles. The results were presented at the IUGG meeting in July. Chuck Brock and I prepared an article on the topic which was published in the December 8 issue of Science.

## **Meetings attended, programs participated in**

International Conference on Ozone in the Lower Stratosphere, Halkidiki, Greece, May, 1995.

IUGG Symposium, Boulder Colorado, July, 1995.

AGU Annual Meeting, San Francisco, December, 1995.

## **Papers at conferences**

“The Growth and Dispersion of Stratospheric Sulfate Particles following the Erup-

tion of Mt. Pinatubo", P. Hamill, H. Houben, R. Young, O. B. Toon, P. B. Russell, R. Bergstrom, J. Xhao, and R. P. Turco, International Conference on Ozone in the Lower Stratosphere, Halkidiki, Greece, May, 1995.

"The Nucleation of Stratospheric Aerosol Particles at the Tropical Tropopause", Patrick Hamill, C. Brock, J. C. Wilson. IUGG XXI General Assembly, Boulder, CO, July, 1995.

"Observations of High Concentrations of Nuclei-Mode Particles near the Tropopause" C. Brock, J. C. Wilson, H. Jonsson, Patrick Hamill. IUGG XXI General Assembly, Boulder, CO, July, 1995.

"Pinatubo Global to Microscale Evolution: A Unified Picture from Space, Air and Ground Measurements" P. B. Russell, J. Livingston, R. Pueschel, J. Pollack, S. Brooks, Patrick Hamill, J. Hughes, L. Thomason L. Stowe, T. Deshler, E. Dutton and R. Bergstrom. IUGG XXI General Assembly, Boulder, CO, July, 1995.

### **Publications**

"Freezing behavior of stratospheric sulfate aerosols inferred from trajectory studies", Azadeh Tabazadeh, Owen B. Toon and Patrick Hamill, *Geophysical Research Letters*, 22, 1725-1728, 1995.

"A time dependent approach to the kinetics of homogeneous nucleation" Terry Olson and Patrick Hamill, *Journal of Chemical Physics*, 104, 1-15, 1996.

"On the growth of ternary system  $\text{HNO}_3/\text{H}_2\text{SO}_4/\text{H}_2\text{O}$  aerosol particles in the stratosphere", Patrick Hamill, A. Tabazadeh, S. Kinne, O. B. Toon and R. P. Turco, *Geophysical Research Letters*, in press (1996).

"Particle formation in the upper tropical troposphere: A source of nuclei for the stratospheric aerosol", C. Brock, Patrick Hamill, H. Johansson, R. Chan, *Science*, 270, 1650-1653 (1995).

### **Papers in Preparation**

"Global to microscale evolution of the Pinatubo volcanic aerosol, derived from diverse measurements and analyses", Phil Russell, J. Livingston, R. Pueschel, J. Pollack, S. Brooks, L. Thomason, P. Hamill, J. Hughes, T. Deshler, E. Dutton and R. Bergstrom. Submitted to *Journal of Geophysical Research*, 1995.

“Black carbon (soot) aerosol in Concorde exhaust”, Rudi Pueschel, S. Verma, G. Ferry, J. Goodman, D. Allen and Patrick Hamill Submitted to *Geophysical Research Letters*, 1995.

“In situ sampling of type I and type II polar stratospheric clouds in the Antarctic stratosphere”, J. Goodman, S. Verma, R. Pueschel, P. Hamill, G. Ferry and D. Webster. Submitted to *Geophysical Research Letters*, 1995.